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इस्पात की चद्दर एवं पत्ती — पूर्ण
प्रक्रमित प्रारूप — विशिष्टि
(छठा पुनरीक्षण)

**Cold Rolled Non-Oriented
Electrical Steel Sheet and Strip —
Fully Processed Type —
Specification**
(*Sixth Revision*)

ICS 77.140.40

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FOREWORD

This Indian Standard (Sixth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Wrought Steel Products Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1955 and subsequently revised in 1962, 1970, 1980, 1994 and 2006. While reviewing this standard in the light of experience gained during these years, the Committee decided to revise it to bring in line with the present practices being followed by the Indian industry and overseas standards of cold rolled non- oriented electrical steel sheet and strip.

In this revision the following modifications have been made:

- a) Amendment No. 1, 2, 3, 4 and 5 have been incorporated.
- b) Additional definitions have been incorporated.
- c) Changes made in clauses **6.1.3**, **7.1.2.1**, Annex B.
- d) Clause **9.2.1** and Clause **10** have been added.

For all the tests specified in this standard (chemical/physical/others), the method as specified in relevant ISO/IEC /JIS/ASTM standard may also be followed as an alternate method.

A conversion factor table is given in Annex A for information.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

COLD ROLLED NON-ORIENTED ELECTRICAL STEEL SHEET AND STRIP — FULLY PROCESSED TYPE — SPECIFICATION (*Sixth Revision*)

1 SCOPE

This standard covers the requirement for non-oriented electrical steel with silicon content up to 3.5 percent, cold rolled, both insulated and uninsulated, fully processed electrical steel and strip primarily intended for static and rotating machines operating at power frequencies.

This standard defines grades of cold rolled non-oriented electrical steel sheet and strip in nominal thicknesses of 0.35 mm, 0.5 mm, 0.65 mm and 1.00 mm.

If required and agreed to between the purchaser and the manufacturer, the typical, physical and mechanical properties of the steel sheets/strips shall be supplied by the manufacturer to the purchaser.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revisions and parties to agreements based on these standards are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

| IS No. | Title |
|-------------------------|--|
| 649:1997 | Methods of testing steel sheets for magnetic circuits of power electrical apparatus (<i>second revision</i>) |
| 8910:2022 | General technical delivery requirements for steel and steel products (<i>first revision</i>) |
| 13795 (Part 1): 1993 | Glossary of terms relating to special alloys: Part 1 Soft magnetic materials |

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 13795 (Part 1) and the following shall supply.

3.1 Electrical Steel Sheet/Strip — Electrical steel/strip is a material used for making cores for rotating electrical machines and static apparatus.

3.2 Non-oriented Electrical Steel Sheet/Strip — Steel sheet/strip having substantially the same magnetic and electrical characteristics in all direction of the plane of the sheet.

3.3 Cold Rolled Electrical Steel Sheet/Strip — Electrical steel sheet/strip which is reduced to final gauge after cold rolling.

3.4 Silicon Steel — Electrical steel made with deliberate alloying addition of silicon.

3.5 Fully Processed Material — Material which does not require further processing by the purchaser to give the specified properties.

3.6 Sheet — A cold rolled flat product in rectangular section of thickness below 5 mm and supplied in straight lengths. The width is at least 100 times the thickness and the edges can be mill, trimmed and sheared.

3.7 Strip — A cold rolled flat product approximately in rectangular cross-section of thickness normally 12 mm or below with mill, rolled trimmed or sheared edges and supplied in coil form.

3.7.1 Wide Strip — Cold rolled strip of width normally equal to or greater than 600 mm.

3.7.2 Narrow Strip — Cold rolled strip of width normally less than 600 mm.

3.8 Coil Interleaves — Laps at the junctions between sub-coils for the purpose of building up larger continuous coils.

3.9 Coil Butt Welds — Butt welds at the junctions between sub-coils for the purpose of building up larger continuous coils.

3.10 Batch — A single charge of the product of one or more cast heat treated together with similar quality grading.

3.11 Stacking Factor — A numeric, less than unity and usually expressed as a percentage, which is defined as the ratio of the uniform solid height of the magnetic material in a laminated core to the actual height (core build up) when, measured under a specified pressure is thus equal to the ratio of the volume of magnetic material in a uniform laminated core to the overall geometric volume in the core.

3.12 Flatness (Wave Factor) — The property of a sheet or of a length of strip which is characterized by the wave factor, that is, by the relation of the height of the wave to its length.

3.13 Insulated Sheet — Insulated sheet shall mean electrical sheets in sheet/strip form coated on both sides with organic or inorganic or combined organic and inorganic materials to provide interlaminar insulation resistance.

3.14 Density — The ratio of mass to the volume of a magnetic material, in kg/m³.

3.15 Anisotropy of Losses — The anisotropy losses is the difference between the specific loss measured perpendicular and parallel to the direction of the rolling expressed as percentage to the sum of two total specific losses measure

$$P, \text{ percent} = \frac{(P_a - P_l)}{(P_a + P_l)} \times 100$$

where

P = anisotropy of losses;

P_a = total specific loss P at 1.5 Tesla perpendicular to the direction of rolling; and

P_l = total loss P at 1.5 Tesla parallel to the direction of rolling.

3.16 Edge Camber — Greatest distance between a longitudinal edge of the sheet and the line joining the two extremities of the measured length of this edge.

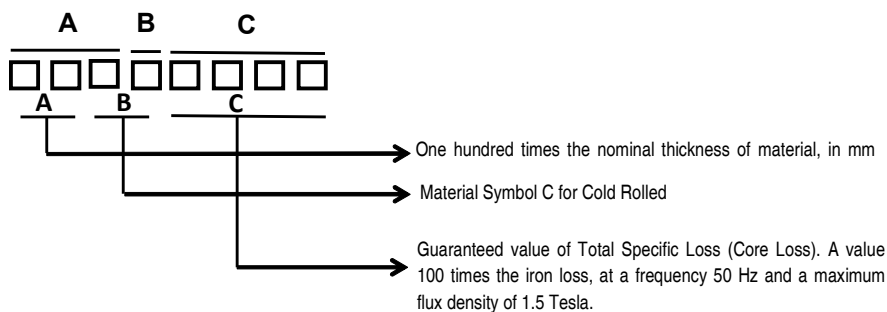
3.17 Number of Bends — Number of alternate bends possible before the appearance in the base metal of the crack visible to the naked eye; it constitutes an indication of the ductility of the material.

3.18 Internal Stresses — Stresses which are characterized by a deviation in the relation to the line of cutting.

4 CLASSIFICATION OF GRADES

This standard covers the grades listed in Table 1, with the forms and condition of supply as specified in IS 8910. The grades are classified according to the maximum value of total loss at a polarization of 1.5T and according to the nominal thickness (0.35, 0.50, 0.65 and 1.00 mm).

5 DESIGNATION



NOTE A = One hundred times the nominal thickness of the product, in mm. B = Material Symbol C for Cold Rolled. C = One hundred times the maximum value of specific total loss in W/kg at 1.5 Tesla, 50 Hz.

Examples

A sheet or strip of 0.50 mm thickness, tested at 1.5 Tesla, 50 Hz and specific total loss 2.70 W/kg shall be designated as 50C270.

6 GENERAL REQUIREMENTS

6.1 Condition of Delivery

6.1.1 The product shall be supplied in the fully processed condition.

6.1.2 The material can be supplied either without insulation or with insulation on one or both sides. If the material is supplied with insulation, the nature of the insulation, its properties and stacking factor and their verification shall be agreed at the time of ordering.

6.1.3 The thickness of the material supplied for each grade shall be as given in Table 1. If the material is required in thicknesses other than those specified in Table 1, these may be supplied as per the properties mutually agreed to between the purchaser and the manufacturer. However, the properties shall be superior to the properties specified in Table 1.

6.1.4 The sizes of the strips and sheets supplied in coil or in cut length shall be subject to mutual agreement between the purchaser and the manufacturer.

6.1.5 When the material is supplied in coils, the following shall be considered as preferred dimensions of the coils for all the grades specified in this standard:

Internal diameter 400/430/450/510/610.

6.1.6 When supplied in cut length form, the packet mass shall not be more than 3.5 tonne or as mutually agreed to between the manufacturer and the supplier.

6.1.7 Interleaves and Welds

Strips can occasionally exhibit welds or interleaves, resulting from the removal of defective zones subject to prior agreement between the parties. If necessary, marking of welds or interleaves may be agreed on at the time of ordering.

6.1.7.1 Small grade coils may be joined together by butt welding to form larger continuous coils in which case the welds shall be marked as for interleaves. The

Table 1 Designation of Electrical Steel Grades*(Clauses 4, 6.1.3, 7.1.1.2, 7.1.2.1, 7.1.2.4 and 9.2)*

| Designation | Nominal Thickness mm | Maximum Specific Total Loss W/kg | | | Minimum a.c. Magnetisation in T | | | Maximum anisotropy of loss percent at 1.5 T | Minimum Stacking Factor | Minimum Numbers of Bends | Conventional Density kg/dm ³ |
|-------------|-------------------------|----------------------------------|-------|-------|---------------------------------|----------|-----------|---|-------------------------|--------------------------|---|
| | | 1.0 T | 1.5 T | | 2500 A/m | 5000 A/m | 10000 A/m | | | | |
| | | 50Hz | 50Hz | 60Hz | | | | | | | |
| 35C230 | 0.35 | 0.95 | 2.30 | 2.90 | 1.49 | 1.60 | 1.70 | ±17 | 0.95 | 2 | 7.60 |
| 35C235 | | 0.95 | 2.35 | 2.97 | 1.49 | 1.60 | 1.70 | ±17 | | 2 | 7.60 |
| 35C250 | | 1.00 | 2.50 | 3.14 | 1.49 | 1.60 | 1.70 | ±17 | | 2 | 7.60 |
| 35C270 | | 1.10 | 2.70 | 3.36 | 1.49 | 1.60 | 1.70 | ±17 | | 2 | 7.65 |
| 35C300 | | 1.20 | 3.00 | 3.74 | 1.49 | 1.60 | 1.70 | ±17 | | 3 | 7.65 |
| 35C330 | | 1.30 | 3.30 | 4.12 | 1.49 | 1.60 | 1.70 | ±17 | | 3 | 7.65 |
| 35C360 | | 1.45 | 3.60 | 4.55 | 1.49 | 1.60 | 1.70 | ±17 | | 3 | 7.65 |
| 50C250 | 0.50 | 1.05 | 2.50 | 3.21 | 1.49 | 1.60 | 1.70 | ±17 | 0.97 | 2 | 7.60 |
| 50C270 | | 1.10 | 2.70 | 3.47 | 1.49 | 1.60 | 1.70 | ±17 | | 2 | 7.60 |
| 50C290 | | 1.15 | 2.90 | 3.71 | 1.49 | 1.60 | 1.70 | ±17 | | 2 | 7.60 |
| 50C310 | | 1.25 | 3.10 | 3.95 | 1.49 | 1.60 | 1.70 | ±14 | | 3 | 7.65 |
| 50C330 | | 1.35 | 3.30 | 4.20 | 1.49 | 1.60 | 1.70 | ±14 | | 3 | 7.65 |
| 50C350 | | 1.50 | 3.50 | 4.45 | 1.50 | 1.60 | 1.70 | ±12 | | 5 | 7.65 |
| 50C400 | | 1.70 | 4.00 | 5.10 | 1.53 | 1.63 | 1.73 | ±12 | | 5 | 7.70 |
| 50C470 | | 2.00 | 4.70 | 5.90 | 1.54 | 1.64 | 1.74 | ±10 | | 10 | 7.70 |
| 50C530 | | 2.30 | 5.30 | 6.66 | 1.56 | 1.65 | 1.75 | ±10 | | 10 | 7.70 |
| 50C600 | | 2.60 | 6.00 | 7.53 | 1.57 | 1.66 | 1.76 | ±10 | | 10 | 7.75 |
| 50C630 | | 2.80 | 6.30 | 7.90 | 1.58 | 1.68 | 1.76 | ±10 | | 10 | 7.75 |
| 50C700 | | 3.00 | 7.00 | 8.79 | 1.60 | 1.69 | 1.77 | ±10 | | 10 | 7.80 |
| 50C800 | | 3.60 | 8.00 | 10.06 | 1.60 | 1.70 | 1.78 | ±10 | | 10 | 7.80 |
| 50C900 | | 3.80 | 9.00 | 11.31 | 1.61 | 1.70 | 1.78 | ±10 | | 10 | 7.80 |
| 50C940 | | 4.20 | 9.40 | 11.84 | 1.62 | 1.72 | 1.81 | ± 8 | | 10 | 7.85 |
| 50C1000 | | 4.40 | 10.00 | 11.90 | 1.62 | 1.72 | 1.81 | ±10 | | 10 | 7.85 |
| 65C310 | 0.65 | 1.25 | 3.10 | 4.08 | 1.49 | 1.60 | 1.70 | ±15 | 0.97 | 2 | 7.60 |
| 65C330 | | 1.35 | 3.30 | 4.30 | 1.49 | 1.60 | 1.70 | ±15 | | 2 | 7.60 |
| 65C350 | | 1.50 | 3.50 | 4.57 | 1.49 | 1.60 | 1.70 | ±14 | | 2 | 7.60 |
| 65C400 | | 1.70 | 4.00 | 5.20 | 1.52 | 1.62 | 1.72 | ±14 | | 2 | 7.65 |
| 65C470 | | 2.00 | 4.70 | 6.13 | 1.53 | 1.63 | 1.73 | ±12 | | 5 | 7.65 |
| 65C530 | | 2.30 | 5.30 | 6.84 | 1.54 | 1.64 | 1.74 | ±12 | | 5 | 7.70 |
| 65C600 | | 2.60 | 6.00 | 7.71 | 1.56 | 1.66 | 1.76 | ±10 | | 10 | 7.75 |
| 65C700 | | 3.00 | 7.00 | 8.98 | 1.57 | 1.67 | 1.76 | ±10 | | 10 | 7.75 |
| 65C800 | | 3.60 | 8.00 | 10.26 | 1.60 | 1.70 | 1.78 | ±10 | | 10 | 7.80 |
| 65C1000 | | 4.40 | 10.00 | 12.77 | 1.61 | 1.71 | 1.80 | ±10 | | 10 | 7.85 |
| 100C600 | 1.00 | 2.60 | 6.00 | 8.14 | 1.53 | 1.63 | 1.72 | ±10 | 0.98 | 2 | 7.60 |
| 100C700 | | 3.00 | 7.00 | 9.38 | 1.54 | 1.64 | 1.73 | ±8 | | 3 | 7.65 |
| 100C800 | | 3.60 | 8.00 | 10.70 | 1.56 | 1.66 | 1.75 | ±6 | | 5 | 7.70 |
| 100C1000 | | 4.40 | 10.00 | 13.39 | 1.58 | 1.68 | 1.76 | ±6 | | 10 | 7.80 |
| 100C1300 | | 5.80 | 13.00 | 17.34 | 1.60 | 1.70 | 1.78 | ±6 | | 10 | 7.80 |

NOTES

1 Properties tested and reported at 60 Hz shall conform to the specified values of above table when tested in importing country at 50 Hz.

2 a.c. Magnetisation can be checked and reported in any value between 2 500 to 10 000 A/m as per mutual agreement apart from above (at 2 500, 5 000 and 10 000).

3 In case any grade that is not covered in Table 1 can be considered, and if the grade designation as defined in clause 4 is followed and properties are certified based on the values in Table 1 to the nearest thickness and then the next best grade within the table.

supplier shall ensure that the welds are made in such a manner as not to damage areas of the coils adjacent to the weld.

6.1.7.2 The edges of parts welded together shall not be so much out of alignment so as to affect the further processing of the material.

6.1.8 Stability

Coils shall be sufficiently tightly wound to prevent collapse to an extent that would prelude their being mounted on a mandrel appropriate to the ordered internal diameter.

6.2 Chemical Composition — The chemical composition of steel is left to the manufacturer's discretion. However, the chemical composition may be provided, if agreed to between manufacturer and the purchaser at the time of placing the order.

6.3 Surface Condition

6.3.1 The surface shall be smooth and clean, free from grease and rust (the same should not be confused with some coloration of insulation coating inherent in manufacturing process). Dispersed defects such as scratches, blisters, aesthetic type physical damages, etc, are permitted if they are within limits of thickness tolerance and not detrimental to method of working or correct use of supplied material. The limit, classification and disposition shall be subject to agreement between the purchaser and the manufacturer.

6.3.2 When an insulation coating is present on the surface of the material, it shall be sufficiently adherent so that it does not become detached during cutting operations. During an alternating bend test, the coating shall not detach after a bend of 90°. If the coating becomes detached during the test, the piece from which the sample was taken shall be subjected to shearing test. During the test, it shall not be admissible for large pieces of the coating to become detached. However, the slight chipping of this coating at the shearing edges shall be tolerated.

7 TECHNICAL REQUIREMENT

7.1 Magnetic Characteristics

7.1.1 Magnetization Test

7.1.1.1 a.c. magnetization test — The Minimum specified values of a.c. magnetization for magnetic field strengths H of 2500 A/m, 5000 A/m, 10000 A/m shall be given in Table 1.

The a.c. magnetization shall be determined in an alternating magnetic field (expressed as a peak value) at 50 Hz

7.1.2 Total Specific Loss/Core Loss

7.1.2.1 The specified values of maximum total specific loss at 50 Hz to be guaranteed at 1.5 T shall be as given in Table 1. They apply –

- for the nominal thicknesses 0.35 mm, 0.50 mm and 0.65 mm to aged or non aged test pieces;
- for the nominal thickness 1.00 mm to non-aged test pieces; and
- the values of the specific total loss at 1.0 T given in Table 1 are for information only.

NOTE — The ageing shall be carried out as specified in IS 649.

7.1.2.2 The test sample shall be prepared and tested as described in IS 649 at a peak magnetic flux density of 1.5 T at 50 Hz. Wherever, relevant the samples shall be annealed in accordance with the manufacturer's recommendations before testing.

7.1.2.3 Anisotropy of losses

If required by the purchaser the anisotropy of losses should be tested. The maximum values of Table 1 should be guaranteed.

7.1.2.4 If agreed to between the purchaser and the manufacturer, the manufacturer shall supply characteristics curves for properties agreed upon mutually.

7.1.2.5 If agreed to between purchaser and the manufacturer, the manufacturer should also give information for the following properties to the purchaser on request:

- Typical electrical resistivity values for each grade, and
- Typical thermal conductivity values for each grade.

7.2 Surface Insulation Characteristics

7.2.1 Unless otherwise specified, fully processed cold rolled electrical sheets shall be supplied without coating, they shall be coated with either organic or inorganic material as specified by the purchaser. The description of the coatings is given in Annex B.

7.2.2 The coating should have uniform colour throughout the surface of the coil tightly adherent to both sides.

7.2.3 If insulated material is required for subsequent annealing this should be stated by purchaser on his enquiry and order. The coating supplied shall withstand annealing under condition specified by the supplier.

7.2.4 Material when supplied with insulation, the nature of the insulation and its properties shall be subject to mutual agreement between the purchaser and the manufacturer.

7.2.5 Method of measurement of insulation resistance shall be as per IS 649.

7.2.6 Thermal Effect on Coating

If agreed between the purchaser and the manufacturer, twelve specimens of the coated strip shall be clamped together under a pressure of 1 N/mm² approximately and heated in a laboratory oven at a temperature of 150°C for a period of 7 days. After cooling to the room temperature the insulation surface resistance (two sides coated) shall be not less than the minimum specified values as mutually agreed to between the manufacturer and the purchaser.

7.2.7 Resistance to Solvents and Cleanliness

If agreed to between the user and the manufacturer, the specimens shall be kept in a container filled with boiling trichloroethylene or xylene for 5 min. After removal and cooling to room temperature, the film should not get soft enough so that it can be wiped off.

8 GEOMETRIC CHARACTERISTICS AND TOLERANCES

8.1 Thickness Tolerances

8.1.1 The nominal thickness of the material are 0.35 mm, 0.50 mm, 0.65 mm and 1.00 mm. The allowable tolerance on the nominal thickness within the same acceptable unit shall be ± 8 percent of the nominal value for thicknesses 0.35 mm and 0.50 mm and ± 6 percent of the nominal value for thicknesses 0.65 mm and 1.00 mm. The additional thickness due to welds, with respect to the measured thickness of the steel sheet or strip shall not exceed 0.050 mm.

8.1.2 The difference in thickness in a direction perpendicular to the direction of rolling shall not exceed 0.020 mm for thicknesses of 0.35 mm and 0.50 mm and 0.030 mm for thicknesses of 0.65 mm and 1.00 mm, the measurements being made at least 30 mm from the edges. This measurement shall be made using a micrometer with an accuracy of 0.001 mm. These tolerances apply only to materials with a width greater than 150 mm. For narrow strip and for materials supplied with as rolled edges, other agreements may be reached while ordering.

8.1.3 The height of the weld, if any and edge burr shall not exceed 50 microns.

8.2 Width Tolerances

8.2.1 This tolerance is applicable to widths less than or

equal to 1250 mm. For the width tolerances a distinction is made between material supplied with edges in the as rolled condition and material delivered with trimmed edges.

8.2.2 For material supplied with trimmed edges, the tolerances of Table 2 shall apply.

8.2.3 For materials supplied with as rolled edges and / or widths above 1250 mm the tolerance on nominal width be a subject of agreement while ordering

Table 2 Width Tolerance
(Clause 8.2)
All dimensions in millimetres.

| S1 No. (1) | Nominal Width 'l' mm (2) | Tolerance mm (3) |
|--------------------------------|---------------------------------------|-------------------------------|
| i) | $l \leq 150$ | +0.2 -0.0 |
| ii) | $150 < l \leq 300$ | +0.3 -0.0 |
| iii) | $300 < l \leq 600$ | +0.5 -0.0 |
| iv) | $600 < l \leq 1000$ | +1.0 -0.0 |
| v) | $1000 < l \leq 1250$ | +1.5 -0.0 |

NOTE — As per agreement, width tolerance can be -ve or +ve or both -ve and +ve subject to tolerance band as given in above table.

8.3 Length Tolerance

The tolerance on length of sheets in relation to length ordered shall be $\begin{matrix} +0.5 \\ -0.0 \end{matrix}$ percent but subject to maximum value of 6 mm.

8.4 Tolerances on sizes other than those covered under **8.1**, **8.2** and **8.3** shall be subject to an agreement between the purchaser and the manufacturer.

8.5 Tolerance on Shape

8.5.2 Out of Squareness

Out of square, tolerances shall not be more than 1 percent of the length and the width.

8.5.3 Edge Camber

Verification of Edge camber applies only to material supplied with trimmed edges, and width greater than 30 mm.

The edge camber shall not exceed for a measuring length of 2 m.

- 2 mm for a nominal width $l > 150$ mm
- 4 mm for a nominal width $l, 30 < l \leq 150$

8.5.4 Residual Curvature

The verification of residual curvature does not apply

to material supplied with as rolled edges and material of width less than or equal to 100 mm. A requirement concerning residual curvature can be specified by agreement when ordering in this cast, the distance between the bottom edge of the test specimen and the supporting plate shall not exceed 35 mm for the products of thicknesses 0.35 mm, 0.50 mm and 0.65 mm. For the thickness 1.00 mm, this distance shall be subject to an agreement between the supplier and the purchaser.

8.6 Flatness (Wave Factor)

This tolerance is applicable to material of width more than 100 mm. The wave factor, expressed as a percentage, shall not exceed 2 percent. For material supplied with as rolled edges the flatness values shall be subject of agreement while ordering.

8.7 Sheet and Strip for Specific Purposes

Material required to tolerances other than those specified in 8.1 and 8.6 shall be subject to agreement between the purchaser and the manufacturer.

9 TECHNOLOGICAL CHARACTERISTICS

9.1 Stacking Factor

The surface quality of the uninsulated cold rolled sheet/strip and when measured in terms of stacking factor as specified in IS 649 shall comply with minimum values given in Table 1. For insulated it is an agreement between the manufacturer and the purchaser.

9.2 Bend Test

The bend test shall be carried out as specified in IS 649. The test piece shall withstand the number of bends as given in Table 1. The radius of jaws shall be 5.0 mm. The test may be terminated when the number of bends exceeds the minimum requirements as given in Table 1, subject to agreement while ordering.

9.2.1 Bend Calculation

First 90° bend is counted as 'First Bend', then through 180° in reverse direction as 'Second Bend' and again when the sample is bend through 180° in the first direction as 'Third Bend' and so on till the fracture / crack appears.

10 INSPECTION AND TESTING

10.1 General

Each mother coil (acceptance Unit) is around 17 MT (Including coils greater than 17 MT, depending on width of material) or the remaining fraction thereof of the same grade and the same nominal thickness. Different acceptance units can be adopted by special agreement.

Except by special agreement, the same rules apply to the inspection of suitability for cutting, surface insulation resistance and tolerances of shape and dimensions.

When the products are delivered in the form of slit coils, the test results applying to the mother coil of acceptance shall apply.

10.2 Selection of Samples

Test samples shall be taken from each acceptance unit. The first internal turn and last external turn of the coils shall be considered as wrapping and not as representative of the quality of the rest of the coil. The selection shall be made from the first internal or external turns, excluding the wrapping turn and outside any welding zones or interleaves. In the case of sheets, the selection shall be made preferably from the upper part of the bundle.

10.3 Preparation of Test Specimens

10.3.1 Magnetic Properties

For the measurement of a.c. magnetisation polarization and total specific loss/core loss using the 25 cm Epstein frame, the test specimen shall consist of a minimum of Epstein test strips as per IS 649 having the following dimensions:

- a) length 280 mm to 320 mm, the lengths being equal within a tolerance of ± 0.5 mm; and
- b) width $30 \text{ mm} \pm 0.2 \text{ mm}$.

Half of the strips shall be cut parallel to direction of rolling and other half perpendicular, giving even distribution across the width of the material. The test strips shall be carefully cut without deformation. Cutting or punching shall be carried out only with well sharpened tools.

10.3.2 Insulation Resistivity

Each test specimen shall be formed from a single sheet or length of strip. The width and length of the test specimen shall be respectively greater than the width and length of the contact assembly. This measurement is destructive; the test specimen can only be used once. To obtain a representative result, test specimens shall be taken from the full sheet width.

10.4 Geometrical Characteristics and Tolerances

For the measurement of thickness, width, flatness and edge camber, the test specimen shall consist of a sheet or a 2 m length of strip.

For the measurement of the residual curvature, the test specimen shall consist of a sample $500^{+2.5}_{-0}$ mm, in

length and of width equal to the delivery width of the sheet or strip.

11 RETEST

11.1 Should a test sample fail, two further samples shall be selected at random from the same batch of material and tested in a same manner.

11.2 If either of both of the retest samples on testing indicates that the core loss is greater than maximum loss specified for the respective grade, the batch represented by these samples shall be taken as not complying with the requirements of that grade.

12 PACKING

The sheets/strips shall be suitably packed in metal protected containers lined with water-proof material lining to avoid any damage and to ensure protection from rust during transit. The method of packing shall be subject to the approval by the purchaser before shipment from manufacturer's works.

13 MARKING

13.1 Every bundle/coil of sheet/strip shall be legibly marked with the following:

- a) Manufacturer's name;
- b) Grade and thickness;
- c) Gross and net mass (at the top of bundle);
- d) Cast number or identification mark by which the sheets/strips may be traced to the cast from which they were made; and
- e) Type of coating, if coated.

13.2 BIS Certification Marking

The material shall be marked with the Standard Mark.

13.2.1 The use of the Standard Mark is governed by the provisions of *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations made thereunder. The details of conditions under which the license for use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

14 TEST CERTIFICATE

The manufacturer shall provide with each consignment, a test certificate giving the following as per the agreement between the manufacturer and the purchaser at the time of placing the order:

- a) Grade;
- b) Nominal Dimension (Thickness/Width/Length (If supplied in Sheet form);
- c) Density;
- d) Specific total loss for each coil/packet;
- e) a.c. magnetization;
- f) Insulation resistance, if coated;
- g) Number of bends;
- h) Anisotropy;
- j) Stacking factor;
- k) Chemical composition;
- m) Insulation thickness;
- n) Adherence;
- p) Resistance to solvent; and
- q) Thermal effect.

15 ORDERING INFORMATION

While placing an order for cold rolled non-oriented electrical steel sheet and strip (fully processed type) covered by this standard, the purchaser should specify, clearly the following:

- a) Grade of electrical steel sheet/strip required (*see* Table 1);
- b) Length, width and thickness of sheets or the width, thickness, maximum and minimum acceptable mass and internal diameter of coils required (*see* Table 1, **6.1.5**, **8.2** and **8.3**);
- c) Number of interleaves and/or butt welds acceptable in a coil (*see* **6.1.7.2**);
- d) Type of coating and nominal thickness;
- e) Any optional test required; and
- f) Any special requirements (*see* **4**, **6.1.4**, **8.4**, **8.7** and **10.1**).

ANNEX A
(Foreword)
CONVERSION FACTOR

| Term (1) | To (2) | From (3) | Conversion Factor (4) |
|---|----------------------------|----------------------------|--------------------------|
| Magnetic flux density (<i>B</i>) | Tesla (Wb/m ²) | Gauss | 10 ⁴ |
| | Gauss | Tesla (Wb/m ²) | 10 ⁻⁴ |
| Magnetic field strength (<i>H</i>) | Ampere-turns/meter | Oersted | 0.0126 |
| | Oersted | Ampere-turns/meter | 79.6 |
| | Ampere-turns/meter | Ampere - turns/inch | 0.0254 |
| | Ampere-turns/meter | Ampere - turns/cm | 0.01 |
| Core loss | Watt/kg | Watt/pound | 0.4536 |
| | Watt/pound | Watt/kg | 2.205 |
| | Watts/kg at 60 Hz(1.5T) | Watts/kg at 50 Hz(1.5T) | 0.79 |
| | Watts/lb at 60 Hz(1.5T) | Watts/kg at 50 Hz(1.5T) | 1.74 |
| Length (<i>l</i>) | Centimetre | Inch | 0.3937 |
| | Inch | Centimetre | 2.54 |
| Area (<i>A</i>) | Square cm | Square inch | 0.155 |
| | Square inch | Square cm | 6.45 |
| Volume (<i>V</i>) | cm ³ | Cubic inch | 0.061 |
| | Cubic inch | cm ³ | 16.4 |
| Mass (<i>m</i>) | gm | Ounce | 0.0353 |
| | Kg | pound | 2.205 |
| | Ounce | gm | 28.35 |
| | Pound | Kg | 0.4536 |
| Tensile strength (<i>R_m</i>) | N/mm ² | Kg/mm ² | 0.102 |
| | Kg/mm ² | N/mm ² | 9.81 |
| Temperature (<i>T</i>) | °C | °F | × 1.8 + 32 |
| | °F | °C | × 0.556 – 17.8 |

ANNEX B

(Clause 7.2.1)

CLASSIFICATION OF SURFACE INSULATIONS OF ELECTRICAL STEEL SHEET,
STRIP AND LAMINATIONS

| Insulation Designation | Insulation Description — Characteristics — Typical Application, Limits of Use | Insulation Designation | Insulation Description — Characteristics — Typical Application, Limits of Use |
|-------------------------------|---|-------------------------------|---|
| C-0 | Oxide that is formed naturally on the steel surface during mill processing. This oxide layer is thin, tightly adherent, and provides sufficient insulating quality for most small cores. The oxide layer will withstand normal stress-relief annealing temperatures. The insulation quality is affected by the oxidizing potential of the user's anneal, that is, the oxidized surface condition may be enhanced by controlling the atmosphere to be more or less oxidizing to the surface. It is not appropriate to assert a maximum acceptable Franklin test current (Insulation resistivity) for this coating. | C-3 | An organic varnish/enamel coating that is applied to the steel surface. It is preferably used for fully processed non-oriented electrical steels. It may be appropriate to specify the surface insulation resistance for this type of coating. This coating generally improves the punchability of the steel and, hence, is quite suitable for stamped laminations. This coating may adversely affect weldability and will not withstand normal stress relief annealing temperatures. The coating is normally suitable for operating temperatures up to about 180 °C. The user should take into account any problems due to coating off-gassing during welding or exposure of the steel coated with this type of coating to elevated temperatures (>180°C). |
| C-1 | An oxide layer that is created on the surface of the steel laminations by contact with an oxidizing furnace atmosphere at the end of the user's heat treatment cycle. This oxide layer is usually bluish to grey in colour. This oxide layer is primarily relevant to steel sheet, strip and laminations in the semi-processed state. It is not appropriate to specify the surface insulation resistance for this type of insulation. | C-4 | A coating formed by phosphating or some other chemical treatment of the steel surface followed by a curing treatment at elevated temperature. This type of coating is used in applications requiring moderate levels of surface insulation resistance. This type of coating will withstand normal stress-relief annealing temperatures but some reduction of the surface insulation resistance may result. It may be appropriate to specify the surface insulation resistance for this type of coating. |
| C-2 | An inorganic insulation coating predominantly comprised of magnesium silicate. It is formed on the surface of grain oriented electrical steel by the reaction of the annealing separator with the steel surface during high temperature annealing. This coating is often referred to as 'mill glass' or 'glass', even though the coating is not technically a glass. This coating is very abrasive. Steels coated with C-2 only are not typically used for stamped laminations. The primary application of this coating is for materials used in wound core transformers. This coating will withstand normal stress-relief annealing temperatures. It is not appropriate to specify the surface insulation resistance for this type of coating. | C-5 | Inorganic or mostly inorganic coating similar to C-4, to which ceramic fillers or film-forming inorganic components have been added to increase the insulating ability of the coating. The coating typically is a phosphate, chromate, or silicate coating, or combination thereof. Such coatings are applied to the steel surface and cured by heating. The coatings can be applied to grain-oriented electrical steels, nonoriented electrical steels, and cold rolled motor lamination steels. A C-5 coating may be applied |

| Insulation Designation | Insulation Description — Characteristics — Typical Application, Limits of Use | Insulation Designation | Insulation Description — Characteristics — Typical Application, Limits of Use |
|------------------------|---|------------------------|---|
| | <p>over top of a C-2 coating for applications in which extra surface insulation is required for ample sheared laminations of grain-oriented electrical steel for cores of power transformers. C-55 coatings are used for applications requiring a high-surface resistivity. It is appropriate to designate a maximum Franklin test current for this type of coating before stress-relief annealing. The required Franklin test current is subject to agreement between the producer and user. The coating will withstand stress-relief annealing up to 1550°F (840°C) in neutral or slightly reducing furnace atmospheres, but some reduction in surface insulation resistivity may occur during the anneal. The coating will withstand burn-off treatments at 600-1000°F (320-540°C) used to remove stator winding insulation during rebuilding of motors. The coating can be used in air-cooled or oil-immersed cores. In some cases, organic components may be added to C-5 coatings to enhance punchability. The applications, use, and properties of such coatings are similar to those of inorganic C-5 coatings. The user should consult the producer if there are particular concerns with coating off-gassing during welding or elevated temperature exposure of the coated steel.</p> | C-6 | <p>Organic-based coating to which inorganic fillers have been added to increase the insulating ability of the coating. The coating is applied to the steel surface and cured by heating. C-6 coatings typically are used for fully processed nonoriented electrical steels. It is appropriate to designate a maximum Franklin test current for this type of coating. The required Franklin test current is subject to agreement between the producer and user. The coating will withstand burn-off treatments used to remove stator winding insulation during rebuilding of motors, done at 600-1000°F (320-540°C), but is not considered to be a coating that will withstand normal stress-relief annealing. The coating generally improves the punchability of the steel, and hence, is suitable for stamped laminations. The user should take into account any problems due to coating decomposition or off-gassing during welding or exposure of the steel coated with this type of coating to elevated temperatures (>180 °C)</p> |

NOTES

1 The surface insulation resistance may be determined according to IS 649.

2 Any requirement for this property and the corresponding method of evaluation should be agreed between the steel producer and the purchaser.

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